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Chemistry in Britain, Feb 1975, pgs 59-64, Indirect  
Electro-chemical Processes, Clarke et al

(58) Field of Search

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## (54) Gas sensor monitoring incorporating gas generation

(57) The sensitivity, response time and the regenerative behaviour of a gas sensor 1 is monitored by producing temporary quantities of gas of the test component and supplying them to the gas sensor. The quantities of gas required for monitoring the sensor are produced electrolytically near the anode and/or at the cathode of generator cell 2 by means of reactions in which water is electrolysed so that local pH displacements occur at the anode and cathode due to production of H<sup>+</sup> and OH<sup>-</sup> and these ions react with compounds such as (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> and KHCO<sub>3</sub> in the electrolyte to produce NH<sub>3</sub> or CO<sub>2</sub> respectively. Fan 4 supplies the gas to the sensor. The generator cell has separated electrodes and either a gel electrolyte to restrict recombination of H<sup>+</sup> and OH<sup>-</sup> ions or a divider such as an ion exchange membrane between the electrodes.

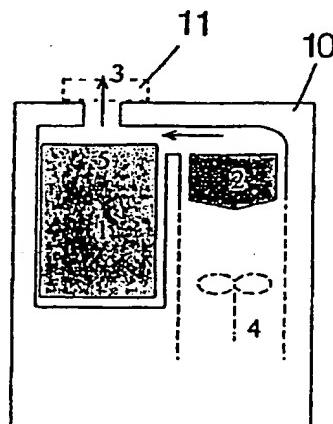


Fig.1

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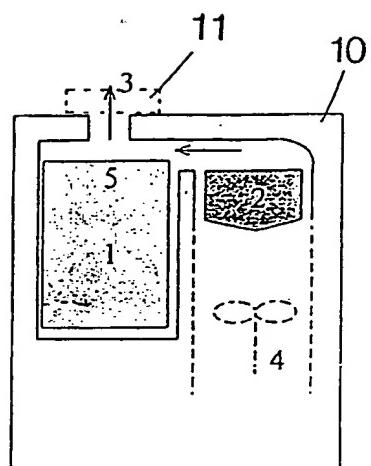


Fig.1

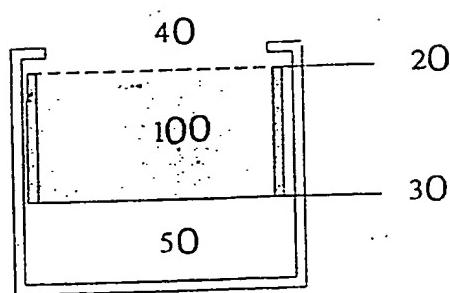
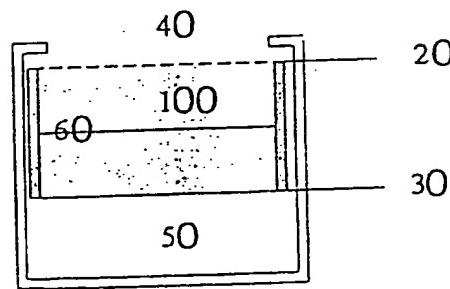
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Fig. 2

METHOD AND EQUIPMENT FOR MONITORING GAS SENSORS AND ALSO  
TO THE APPLICATION OR USE THEREOF

DESCRIPTION

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The invention relates to a method and also to an item of equipment for monitoring gas sensors in accordance with the first part of claims 1 and 5. In addition to this, there are specified a plurality of uses in accordance with the invention of items of equipment functioning in accordance with the invention of items of equipment functioning in accordance with the method in accordance with the invention.

BACKGROUND OF THE INVENTION

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A method as well as an item of equipment of the type in accordance with the prior art is known from DE 26 21 677. There, a method as well as an item of equipment are described with which, or in which, temporary quantities of gas of the test component are produced and are supplied to the gas sensor for monitoring the sensitivity and/or the response time and/or the regenerative behaviour thereof. Thereby, the quantities of gas which are employed for the monitoring process are taken either from a filled reservoir or are produced by a chemical or direct electrochemical reaction. This method of generating gases is installed in static gas analysis systems and serves for calibrating the displayed test value.

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Since the prior application of use related to static gas analysis systems, the amount of space or the space requirement for such gas generators has not, up to now, presented any problems. If, on the other hand, one wants the gas analysis system or the gas analysing devices to be comprised in a smaller structure, then the gas generators of known type are no longer applicable.

## SUMMARY OF THE INVENTION

Consequently, the object of the invention is to develop a  
5 method or an equipment of the type in accordance with the prior art in such a way that the gas generators can be fitted into small-sized gas analysing devices and, moreover, that there thereby results a use in accordance with the invention for specific analysing devices.

10 The posed object is achieved, insofar as a method in accordance with the first part of claim 1 is concerned, by the subsequent features of claim 1. Further advantageous developments of the method are specified in  
15 the claims 2 to 4.

Insofar as an item of equipment in accordance with the first part of claim 5 is concerned, the posed object is achieved in accordance with the invention by the  
20 subsequent features of claim 5. Further developments are specified in the claims dependent on claim 5.

The many diverse ways, in which the equipment in accordance with the invention and which is made to  
25 function in accordance with the method in accordance with the invention, can be put to use, are set forth in the remaining claims which are set out as use claims.

It is thereby achieved, due to the invention in  
30 accordance with this method, that the process of generating gas can be performed in a considerably smaller structure. Due to this, one has been able to achieve such a reduction in the current consumption of these, mainly electrochemically functioning generators, that they can be utilised for the deployment of portable gas warning devices in accordance with the usages in accordance with  
35 the invention. The main requirement for their use in

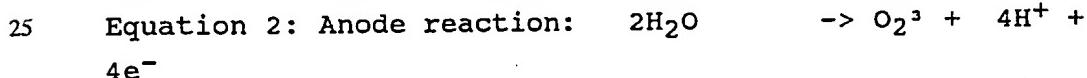
portable gas analysis or gas warning devices is that the latter, insofar as their current supply is concerned and in contrast to static devices, have to be able to be fed merely by means of an accumulator or a battery. By virtue  
5 of the present invention, it is possible to miniaturise the gas generators in such a way that they are of approximately the same size as the miniaturised gas sensors, which are usually in the form of gel sensors, used in transportable gas warning devices. By virtue of  
10 this property, that the generators now have a very small construction, it is not only possible to employ them in portable gas warning devices because of their constructional dimensions and their very low current consumption, but also, over and above this, there is the  
15 advantage that these gas warning devices are not only capable of analysing or detecting a single component of the gas but also that it is possible to adopt a multiple arrangement of different gas sensors sensitized to different components of the gas and, in correspondence therewith, to provide the appropriate number of different  
20 gas generators. There thus ensue, from the reduction in the structural size of the gas generators, not only constructional aspects but also functional ones, namely those for the detection of different components of the  
25 gas by means of the same device.

The development of gas by displacing the pH is of course basically known, but it is new when tied up in a manner in accordance with the invention. One obtains the wanted  
30 components of the gas by electrochemically acidifying or alkalisising a salt solution in combination with the corresponding acid/base reactions. The process of acidification or alkaliisation is effected in the electrochemical manner described, by electrolysing water.  
35 The local changes in pH, which occur in the course of electrolysing aqueous solutions, are described in "pH-

Changes at Near-Electrode Surfaces, Journal of Applied  
Electrochemistry, 13 (1983) p 189".

In the present invention, the generation of the gas does  
5 not occur by virtue of direct reactions at the electrodes  
but rather, by virtue of the secondary reactions of the  
actual products of the electrolysis.

When electrolysing aqueous solutions,  $H^+$  and  $OH^-$  ions are  
10 formed in addition to the gases  $H_2$  and  $O_2$ . If these  
products of the reactions at the anodes and cathodes do  
not recombine, they can enter into further acid-base  
reactions. This situation is achieved in the present  
invention by virtue of the spatial separation of the  
15 electrodes or, for obtaining a more compact structure, by  
means of divided cells which are separated either by  
means of diaphragms or ion exchange membranes. A further  
way of setting up this chemical situation is to fill the  
cells with inspissate or gel-like electrolyte so that  
20 reduced ion migration speeds then occur. The following  
chemical reactions occur at the electrodes during the  
electrolysis of water

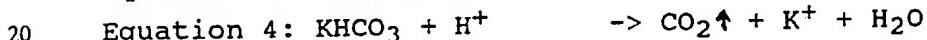
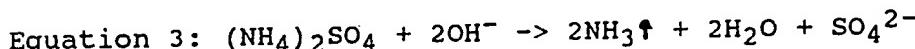


The increase in pH at the cathode occurs through the  
formation of the hydroxyl ion presented above in Equation  
30 1. By contrast, a reduction in pH occurs at the anode due  
to the formation of protons (Equation 2). These  
displacements of the pH are localised to the vicinity of  
the respective electrodes when the electrolysis times are  
short. These displacements of the pH are again  
35 neutralised, by diffusion and re-mixing when the cells  
are not divided. If, on the other hand, any intensive re-  
mixing of the electrolyte is avoided, for example, by

absorption in an appropriate absorption means, then the change in the pH values is locally very marked and acid/base reactions having high yields can be started.

5      Base gases can be produced by virtue of an increase in the pH and acidic gases can be produced by virtue of a decrease in the pH. For example, ammonia is developed by alkalisng an aqueous solution of ammonium salts in accordance with the Equation 3 which is described hereinafter. If the cathode in the form of a sieve is located directly over the surface of the gas, then the ensuing ammonia can escape into the gas space together with the hydrogen which is likewise formed at the cathode. Equation 4 describes the production of CO<sub>2</sub> by 10      acidifying a KHCO<sub>3</sub> aqueous solution for example.  
15

The said reaction Equations 3 and 4 are as follows:



20      The invention is suitable for manufacturing all of the gases that can be produced by means of acid-base reactions insofar as these do not enter into any direct electrode reactions. The latter can be controlled 25      however, by the selection of appropriate electro-catalysing materials.

30      The electrochemical cells may, as already mentioned above, be either divided or undivided. In a divided cell, the separation may be effected either by means of diaphragms or by means of corresponding ion exchange membranes. The undivided cell is realised, in the light of the chemical situation mentioned above, by virtue of 35      distancing the electrodes sufficiently, by using inspissate electrolytes or by use of gel electrolytes.

Thus, overall, by making use of the method in accordance with the invention in the equipment in accordance with the invention, one obtains the result that the generator as such, has an extremely small structure. Consequently,  
5 it is possible to integrate them into likewise small-sized gas monitoring or gas analysing devices. From this, there results a usage in accordance with the invention, in portable gas warning devices. Moreover, due to the miniaturisability of the equipment, which also results  
10 from the method of operation, there likewise arises the possibility of integrating a whole series of gas generators for different components of the gas into a device which is correspondingly equipped with different sensors and which can thus detect different gases.

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#### BRIEF SUMMARY OF THE DRAWINGS

The invention is illustrated in the drawing and will be explained in more detail hereinafter.

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Figure 1 shows a schematic sketch of the equipment in accordance with the invention and

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Figure 1 shows, in the left part, a gas generator cell using a gel electrolyte and, in the right part, a gas generator cell using an aqueous solution as the electrolyte.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

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Figure 1 shows a system which can be utilised, for example, in gas warning devices or gas analysing devices. A gas sensor 1 is disposed within a housing 10. The housing 10 is open at the location 3 and the gases to be analysed can thus enter. Furthermore, the gas sensor 1 is provided with an entrance opening 5 through which the gas that is to be tested can enter into the sensor. For the

that is to be tested can enter into the sensor. For the case that the sensor 1 is sensitized to an extremely poisonous gas i.e. in the event that correspondingly toxic gases have to be released by the generator cell 2, 5 the opening 3 can be closed by the cover 11 during the test phase. A fan 4 is provided in order to supply the gas released by the generator cell 2 to the sensor 1. It is important to mention here, that only temporary quantities of gas are released by the generator i.e. 10 amounts of gas are released for only short periods of time. This is realised by means of an electrical control means which is not further illustrated here.

In the upper part of the picture, Figure 2 shows a system 15 for producing NH<sub>3</sub> which can be utilised as a generator cell 2 in an arrangement in accordance with Figure 1. A gel 100 comprising ammonium sulphate is located between two platinum electrodes 20 and 30 of which the upper electrode 20 is implemented in the form of a grid. The 20 upper electrode is connected up as a cathode 20, the lower one as an anode 30. When implementing the water electrolysis, ammonia and hydrogen, which diffuse away from the generator cell, escape from the cathode 20 into the gas space 40. After the current has been switched off, 25 the concentration profiles for the individual ions rebalance themselves by means of a diffusion process in the gel, and the cell is then ready again to produce fresh surges of gas by means of which the monitoring of the gas sensor is effected. If a gel type electrolyte is not used but rather, 30 an aqueous solution of ammonium sulphate is used as the electrolyte, then, as described above, the chemical situation illustrated is set up by dividing up the generator cell. This situation is illustrated in the lower part of Figure 2. Here, the 35 generator cell is divided by an ion exchange membrane 60 which, for example, may consist of "Nafion" from the

DuPont Company. The lower surface of the sensor leads into the counter electrode gas space 50.

Defined surges of gas can be produced for example, by operating the current source in pulsed manner, the surges being adapted, as regards their strength or intensity and duration, to the sensitivity of the test cell that is to be monitored. Pulsed operation has the additional advantage that the electrolysis can be implemented at middling to high current densities, whence high product yields thereby occur. When integrating such a gas generator into a gas warning device, it is not only important for the realisation of the invention that the gas generator should also release the gas component, to which the sensor is sensitized, in sufficient quantities, but also that the quantity released must be matched in appropriate manner to the detection limits and to the test range of the sensor. Furthermore, as already presented above, one must take care, in the case of highly toxic gases, that gas-dynamics and/or device-related safety measures should be built in, the measures being such as to avoid external exposure to poisonous gases when portable gas warning devices that are to be worn by personnel are put into use. However, for the case where the devices, although they are portable, are usually employed for operation in working areas in which personnel are present, for example, by being hung on a wall, then, in dependence on the selection of the test gas, such safety precautions are not necessary.



The  
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Office  
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Application No: GB 9514055.4  
Claims searched: 1 - 3, 8, 10 and 12.

Examiner: D J Mobbs  
Date of search: 4 October 1995

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:  
UK Cl (Ed.N): C7B BCAX; G1B BBS; G1N NAHK, NAHAS, NBKT, NCGB.  
Int Cl (Ed.6): G01N 33/00.  
Other: ONLINE: WPI, CLAIMS, JAPIO.

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
Y	GB 2254696 A THORN EMI	1, 3, 8, 10
X	GB 1552538 (equivalent to DE 2621677) BAYER - see particularly page 7 line 43 - page 8 line 53.	1, 2
Y	US 4460448 DOW CHEMICAL	1, 2
Y	Chemistry in Britain, February 1975, pages 59 - 64, Indirect Electrochemical Processes, Clarke et al.	1 - 3, 8, 10

- X Document indicating lack of novelty or inventive step  
Y Document indicating lack of inventive step if combined with one or more other documents of same category.  
& Member of the same patent family
- A Document indicating technological background and/or state of the art.  
P Document published on or after the declared priority date but before the filing date of this invention.  
E Patent document published on or after, but with priority date earlier than, the filing date of this application.

provided electrically and/or mechanically actuatable means which prevent any escapage of the quantities of test gas from the gas space during the test phase.

- 5     5. Equipment for monitoring a gas sensor as in Claim 4,  
wherein,  
the gas generating cell is an electrolytic cell.

6. Equipment for monitoring a gas sensor as in Claim 4,  
wherein,  
the electrically and/or mechanically actuatable means  
consists of an electrically closable cover.

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7. Equipment for monitoring a gas sensor as in Claim 4,  
wherein,  
the electrically and/or mechanically actuatable means  
comprises an element for producing gas streams, which  
10 element concentrates the quantities of test gas on the  
gas sensor during the test phase.

8. Portable gas warning device including a gas generator  
functioning as in the method Claim 1.

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9. Portable gas warning device including a gas generator  
as in the apparatus Claim 4.

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10. Portable gas warning device including at least one  
gas generator functioning as in the method Claim 1.

25

11. Portable gas warning device including a plurality of  
sensors which are sensitized to different components of  
the gas and including a plurality of gas generators that  
produce the different components of the gas.

12. Methods of monitoring gas sensors as claimed in claim  
1 and as herein described.

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13. Equipment for monitoring gas sensors as claimed in  
claim 4 and as herein described.

14. Portable gas warning devices as claimed in claim 11  
and as herein described.

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